D. Remarks

Rejection of Claims 1, 3, 5-7, 9 and 11 Under 35 U.S.C. §102(e) or §103(a) based on U.S. Patent No. 6,242,323 (*Ishitsuka et al.*).

The rejection of claims 1, 3 and 5 will first be addressed.

The invention of amended claim 1 is directed to a semiconductor device that includes a trench element separation region including a trench formed in a surface of a semiconductor substrate. An oxide film is formed on inner walls of the trench.

A trench filling insulating material fills the trench and has edges above the inner walls of the trench. Inner wall edges in a top section of the trench and edges of the trench filling insulating material are formed to be essentially located on the same plane when viewed in cross section. Further, the edges of the trench filling material are defined by side edges of a sacrificial layer formed by a pullback etching process including a neutral radical performed for the trench filling process.

As is well established, anticipation requires the presence of a single prior art reference disclosure of each and every element of the claimed invention, arranged as in the claim.[1] Alternatively, to establish a prima facie case of obviousness, a rejection must meet three basic criteria. First, there must be some suggestion or motivation to modify a reference or combine reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference(s) must teach or suggest all claim limitations.

The cited reference *Ishitsuka et al.* does not show a trench filling material with edges defined by side edges of a sacrificial layer, as recited in amended claim 1. Further, the cited reference does not show or suggest that such edges are defined by side edges formed by a pullback etching process. Finally, the cited reference does not show edges of a trench filling material defined by side edges formed by a pullback etching process that includes a neutral radical.

Ishitsuka et al. shows a process for forming an isolation structure. As shown in FIG. 40 of *Ishitsuka et al.*, such an element isolation structure can include a silicon nitride film (3) (argued to correspond to Applicant's sacrificial layer), a groove (4), a silicon oxide film formed

[1] See Lindemann Maschinenefabrick GmbH v. American Hoist & Derrick Col., 221 USPQ 481, 485 (Fed. Cir. 1984).

on a surface of the groove (not labeled), a silicon nitride film (6) formed on the silicon oxide film, and an embedded silicon oxide film (7).

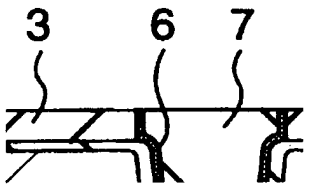
Embedded silicon oxide film (7), argued to correspond to Applicant's "trench filling insulating material", does have an edge above the inner walls of the groove (4). However, such an edge is not defined by side edges of silicon nitride film (3).

The common ordinary definition of "define" is as follows:

> **2 a :** to fix or mark the limits of **:** **DEMARCATE** <rigidly *defined* property lines>...[2]

As shown by the below portion of FIG. 40 of *Ishitsuka et al.*, side edges of embedded silicon oxide film are fixed or have limits marked by silicon nitride film (6), and not silicon oxide film (3).

Layer 6 defines the edge of oxide film 7, not layer 3.



Thus, *Ishitsuka et al.* shows side edges of an embedded silicon oxide film that are defined by silicon nitride film (6). It is noted that silicon nitride film (6) cannot be construed as a sacrificial layer, as the layer is not sacrificed, being retained in the isolation structure (see *Ishitsuka et al.*, FIGS. 41 to 44, which show silicon nitride layer 6 is retained, not sacrificed).

Secondly, the embedded silicon oxide film (7) of *Ishitsuka et al.* does not have edges defined by side edges formed by a pullback etching process.

To better understand this claim limitation, Applicant will review effects of a pullback etching process. A pullback etching process produces structural differences in a resulting sacrificial layer. These differences were clearly described in the Specification:

> The step of etching the silicon nitride film **203** is called a pullback process. Edges **206** of the silicon nitride film **203a** move backward from the top sections of the

[2] Merriam-Webster On-Line Dictionary.

trench and leave the formation region of the liner oxide film **205**.[3]

The above portion was referring to submitted reference U.S. Patent No. 5,981,356 (*Hsueh et al.*). As shown by the below copy of FIG. 1 of *Hsueh et al.*, prior to the pullback etching process, silicon nitride patterning layer (115) has edges in one position. However, as shown in following FIG. 2, the pullback etching results in the edges of mask sections (115A and 115B) being moved away from trench (120) (i.e., being pulled back) from their original positions. Thus, a sacrificial layer subjected to a pullback etching process has structural differences from a layer that is not subject to such a pullback etching.

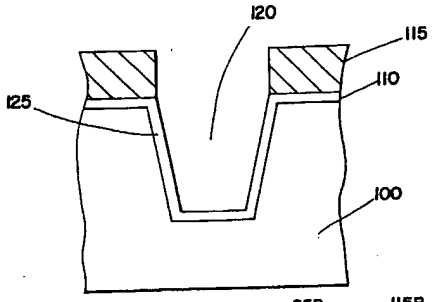


Fig. 1

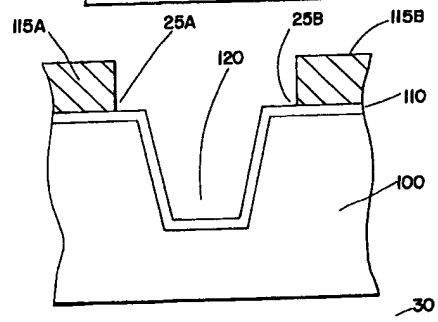


Fig. 2

Sections 115A and 115B are structurally different from layer 115 after pullback etching. Side edges of sections 115A and 115B are further from trench 120.

From the above understanding of pullback etching, as explicitly described by the Specification and understood by those skilled in the art, it is clear that such a limitation is not shown or suggested by the cited reference *Ishitsuka et al.* If reference is made to FIGS. 36 to 40 of *Ishitsuka et al.*, it is clear that silicon nitride layer (3) is never subjected to a pullback etching process. In fact, the reference appears to teach away from such a limitation by forming silicon nitride layer (6) over silicon nitride layer (3), thus protecting such a layer from any structural changes. Accordingly, the resulting isolation structure of *Ishitsuka et al.* differs from that of Applicant by having side edges that encroach closer to groove (4).

Applicant does not believe *Ishitsuka et al.* shows or suggest an edge defined by side

[3] Applicant's Specification, Page 5, Line 23 to Page 6, Line 2.

edges formed by a pullback etching process that includes a neutral radical.

To better understand this claim limitation, Applicant will review structural differences introduced by of a pullback etching process that includes a neutral radical. Conventional approaches form a silicon oxide layer in a trench by oxidizing a surface. This oxidation step has particular effects on the structure of a silicon nitride film (e.g., sacrificial layer).

> [T]he surface of trench **4** may be thermally oxidized... to form a liner oxide film **6**... with a thickness of about 20 nm...By using thermal oxidization to form the liner oxide film **6**, the surface of silicon nitride film **3** may be slightly modified to an oxide nitride film. The oxide nitride film may be referred to as a modified layer. The present invention may remove the modified layer with extremely high accuracy using a method as will be described in detail later in conjunction with FIG. 3.[4]

Thus, Applicants' Specification establishes that such a thermal oxidation step forms an oxide nitride film on silicon nitride film **3**. The cited reference *Ishitsuka et al.* appears no different than this conventional case. *Ishitsuka et al.* performs a similar, if not same, thermal oxidation.

> [A]s shown in FIG. 37, silicon oxide film 5 was formed on the inside wall of groove 4a...in the same manner as in Examples 1 to 3...[5]
>
> EXAMPLE 1...[T]he surface of silicon substrate 31 was thermally oxidized to a thickness of about 30 nm, for example, in a dry oxidative atmosphere at 900° to 1,000° C. to form a heat (or thermal)-oxidized film 35 on the inside wall of the groove (110 in FIG. 3).[6]
>
> EXAMPLE 2... The groove trenched on silicon substrate 31 was thermally oxidized to a depth of about 30 nm in an oxidative atmosphere of H_2/O_2 gas mixture in a gas flow rate ratio of H_2/O_2 ($O<r\leq 0.5$) to form an element isolation, thermally oxidized film 35 (210 in FIG. 6).[7]

Because the invention of *Ishitsuka et al.* undertakes such oxidation steps, in the resulting structure of *Ishitsuka et al.*, as indicated by Applicant's Specification and understood by those

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[4] Applicant's Specification, Page 5, Line 23 to Page 6, Line 2.
[5] *Ishitsuka et al.*, Col. 26, Lines 55-58.
[6] *Ishitsuka et al.*, Col. 15, Lines 6-10.
[7] *Ishitsuka et al.*, Col. 17, Lines 43-47. Note, this example (Example 2) is the same as Example 3.

skilled in the art, a modified layer of oxide nitride would be formed on the silicon nitride film 3.

However, while a silicon nitride film 3 of *Ishitsuka et al.* can include a modified oxide nitride layer due to oxidation steps, such a modified oxide nitride layer is never subjected to a pullback etching process that includes a neutral radical, as set forth in claim 1. In fact, as previously noted, *Ishitsuka et al.* teaches away from such a limitation by forming a second silicon nitride film (6) over silicon nitride film (3), essentially trapping any oxide nitride layer underneath.

A pullback etching process that includes a neutral radical introduces structural differences distinguishable from *Ishitsuka et al.* As emphasized above, *Ishitsuka et al.* does not show or suggest any pullback etching, thus the edges of silicon nitride film (3) of *Ishitsuka et al.* will be more inset with respect to the groove (4). Further, Applicant's unique pullback etching with a neutral radical can establish a side edge of a sacrificial layer with more precision. As evidence in support of such differences, Applicant has previously submitted Experimental Results (Table 1 of the Specification), and Etch Amount versus Etch Time Results (FIGS. 4 and 5 of the Application).

In summary, the cited reference *Ishitsuka et al.* has distinct differences from Applicant's claim 1 invention. *Ishitsuka et al.* shows a trench filling material with edges that are <u>not</u> defined by side edges of a sacrificial layer, but rather top edges of a retained layer. Further, in *Ishitsuka et al.*, side edges of sacrificial layer are <u>not</u> formed by a pullback etching process, and thus have increased encroachment than the claim 1 sacrificial layer. Finally, in the cited reference side edges of sacrificial layer are <u>not</u> formed by a pullback etching process that includes a neutral radical. Accordingly, the definition of the edges of the trench filling material lacks the precision achievable in the claim 1 invention.

For all of these reasons, this ground for rejection is traversed.

The rejection of claims 7, 9 and 11 will now be addressed.

Claim 7 is directed to a semiconductor device having a trench element separation region with a trench that separates a first doped channel of a first insulated gate field effect transistor (IGFET) from a second doped channel of a second IGFET. An oxide is formed on inner walls of the trench.

A trench filling insulating material fills the trench and has edges above the inner walls of the trench. Inner wall edges in a top section of the trench and edges of the trench filling insulating material are formed to be essentially located on the same plane when viewed in cross section. Further, the edges of the trench filling material are defined by side edges of a sacrificial layer formed by a pullback etching process including a neutral radical performed before filling the trench.

To address this ground of rejection, Applicant incorporates by reference the remarks set forth above for claim 1. Namely, that the reference *Ishitsuka et al.* does not show or suggest a trench filling material with edges defined by side edges of a sacrificial layer. Further, *Ishitsuka et al.* does not show or suggest that such side edges are formed by any pullback etching process, let alone a pullback etching process including a neutral radical.

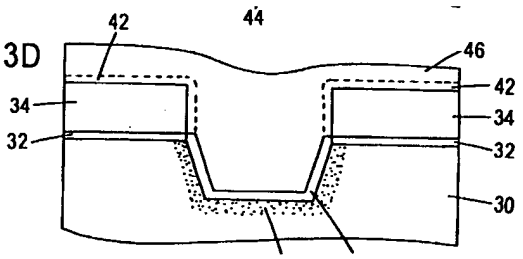
Rejection of Claims 7, 9 and 11 Under 35 U.S.C. §102(e) or §103(a) based on U.S. Patent No. 6,258,697 (*Bhakta et al.*).

The cited reference *Bhakta et al.* does not show "edges of the trench filling material are defined by side edges of a sacrificial layer", as recited in claim 7.

As previously noted by Applicant, and shown by the below copy of FIG. 3D from *Bhakta et al.*, edges of a trench filling material 46 are defined by oxide liner 42 not polish stop layer 34 (argued to correspond to Applicant's sacrificial layer).

Edges of trench filling material 46 are defined by oxide line 42, not layer 34

FIG. 3D



In *Bhakta et al.* layer 42 is deposited over a wafer, and is never described as being removed:

> In accordance with the present invention, the wafer is placed in a LPCVD chamber to deposit the high temperature oxide.[8]

[8] *Bhakta et al.*, Col. 5, Lines13-15.

The rejection has not addressed this showing by Applicant.

For this reason alone, this ground of rejection is believed to be traversed.

In addition or alternatively, to address this ground of rejection Applicant incorporates by reference herein the same general comments set forth above for claim 1 with respect to "pullback etching process" limitations and "pullback etching process including a neutral radical" limitations. Namely, that *Bhakta et al.* does not show or suggest such limitations, and such limitations introduce structural differences that clearly distinguish the invention from the cited reference.

The present claims 1, 3, 5-7 and 9-11 are believed to be in allowable form. It is respectfully requested that the application be forwarded for allowance and issue.

Respectfully Submitted,

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